Optical Fiber Bragg Grating Thermal Compensating Device and Method for Manufacturing Same

FIELD OF INVENTION

This invention is related to optical communication passive element packages and manufacturing methods thereof, in particular to a plurality of optical fiber Bragg grating thermal compensating devices and methods for manufacturing same.

BACKGROUND OF INVENTION

Optical Fiber Bragg grating (FBG) are commonly implemented in various components for manufacturing of dense wavelength division multiplexing (DWDM), such as FBG stabilizing laser source, and various DWDM devices used in multiplexer, de-multiplexer, and optical add-drop multiplexer (OADM). However, in actual implementation, increment of environmental temperature may affect the performance of the FBG. Because the grid pitch and index of refraction of the FBG determine the central frequency of the reflected light, special care must be given to ensure the precision of the FBG. Since increment of environmental temperature will change the index of refraction of the FBG causing increment of the wavelength of the optical fiber thereby deviating from the designated central wavelength, measures shall be taken to prevent occurrences of such changes.

Fig. 9 illustrates a conventional FBG thermal compensating device using a bi-metal construction, where the device comprises two arms 13, 13' and two metal sheets 14, 15. The two metal sheets 14, 15 are soldered to one another and the two arms 13, 13' are soldered to the opposing sides of the metal sheets 14, 15, wherein one of the metal sheets has a thermal expansion coefficient that is smaller than the thermal expansion coefficient of another metal sheet.

Though such a thermal compensating device can reduce thermal effects to the optical fiber, the tolerances accumulated during the manufacturing and

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packaging processes prevent the compensating value of such a device from reaching the desired precision.

Fig. 10 illustrates another conventional FBG thermal compensating device using a bi-metal construction, where the device comprises two metal blocks 21, 22 of complimentary configurations, wherein one of the metal blocks has a thermal expansion coefficient that is smaller than the thermal expansion coefficient of another metal block. FBG 17 is affixed between the two metal blocks. The two metal blocks 21, 22 are affixed to one another through pre-loaded bolts 30 so as to reduce thermal effects to the FBG 17.

Though such a thermal compensating device can reduce thermal effects to the optical fiber, its complicated construction and the need of an additional pre-loading process cause difficulty in manufacturing and increase manufacturing cost.

SUMMARY OF INVENTION

It is, thus, an object of this invention to resolve the above problems by providing a plurality of compensating devices for correcting temperature deviation of fiber grids and methods for manufacturing the same. These devices include means for compressing the fiber grids while the optical fiber experiences an increment in temperature.

In one embodiment, the compressing means includes at least one metal block or thin film being affixed or suspended to a substrate, and fiber grids being cured to the substrate and/or the metal block under a thermal state, or fiber grids being affixed to the substrate and/or the metal block while the fiber grids are under tension.

This invention further discloses methods for manufacturing such devices.

The FBG thermal compensating devices according to this invention consist the advantages of simple constructions and simplified manufacturing processes.

One of the devices can resolve the heat-dissipating problem so as to allow immediate response of the metal block to the thermal expansion of the

fiber grids. Another device allows rapid positioning and manufacturing. One of the devices allows the fiber grids to be directly secured to a thermal compensating substrate without needing additional pre-processes. During the manufacturing processes, AB thermally cured adhesive can be implemented to affix the fiber grids to the device under a thermal state so as to eliminate the implementation of pre-loading. The device can also be placed under a thermal state, after the process of thermal curing, for a pre-determined period of time so as to perform annealing to the fiber grids thereby further simplifying the manufacturing process.

Other aspects and advantages of the present invention are listed in the following detailed description accompanied by the drawings, which also illustrates by way of examples the principles of the invention.

BRIEF DESCRIPTION OF DRAWINGS

Fig. 1 is a top plan view illustrating a first embodiment of an FBG thermal compensating device according to this invention;

Fig. 1A is a schematic plan view illustrating the first embodiment of Fig. 1 further including a manually adjusting means;

Fig. 2 is a top plan view illustrating a second embodiment of an FBG thermal compensating device according to this invention;

Fig. 2A is a schematic view illustrating the second embodiment of Fig. 2 further including a manually adjusting means;

Fig. 3 is a top plan view illustrating a third embodiment of an FBG thermal compensating device according to this invention;

Fig. 3A is a schematic view illustrating the third embodiment of Fig. 3 further including a manually adjusting means;

Fig. 4A is a flowchart illustrating the method for manufacturing the FBG thermal compensating device of Fig. 1;

Fig. 4B is a flowchart illustrating an alternative method for manufacturing the FBG thermal compensating device of Fig. 1;

Fig. 4C is a flowchart illustrating the method for manufacturing the FBG thermal compensating device of Fig. 2;

Fig. 4D is a flowchart illustrating an alternative method for manufacturing the FBG thermal compensating device of Fig. 2;

Fig. 4E is a flowchart illustrating an alternative method for manufacturing the FBG thermal compensating device of Fig. 3;

Fig. 5 is a comparison chart illustrating the compensation result of the first embodiment;

Fig. 6 is a top plan view illustrating a fourth embodiment of an FBG thermal compensating device according to this invention;

Fig. 6A is a schematic view illustrating the fourth embodiment of Fig. 6 further including a manually adjusting means;

Fig. 7 is a top plan view illustrating a fifth embodiment of an FBG thermal compensating device according to this invention;

Fig. 7A is a schematic view illustrating the fifth embodiment of Fig. 7 further including a manually adjusting means;

Fig. 8A is a flowchart illustrating a method for manufacturing the FBG thermal compensating device of Fig. 6;

Fig. 8B is a flowchart illustrating another method for manufacturing the FBG thermal compensating device of Fig. 6;

Fig. 8C is a flowchart illustrating a method for manufacturing the FBG thermal compensating device of Fig. 7;

Fig. 8D is a flowchart illustrating another method for manufacturing the FBG thermal compensating device of Fig. 7;

Fig. 9 illustrates a conventional FBG thermal compensating device using a bi-metal construction; and

Fig. 10 illustrates another conventional FBG thermal compensating device using a bi-metal construction.

LIST OF REFERENCE NUMERALS

10,10',10",6,7	compensating device
12,12',12",62,72	substrate
14,14',14"	first metal block
16,16',16",66,76	optical fiber
18,18',18",68,78	fiber Bragg grid
19"	compensating block
20, 20', 20",60,70	manually adjusting means
22, 22', 22"	second indent
24, 24', 24"	threaded rod
26, 26', 26"	positive screw thread
28, 28', 28"	counter screw thread
122,122',122",622,722	first indent
124,124'	space
142'	second metal block
162,162',163,163',164	affixing points
221, 221', 221"	first arm
222, 222', 222"	second arm
64	metal thin film
74	floating metal block
75	elastically deformable adhesive
662, 663, 762, 763	affixing points

741, 742	affixing pointsL1 first length
L2	second length
L3	third length
L4	fourth length
L5	fifth length
L6	sixth length
LG	overall length of grid

DETAILED DESCRIPTIONS OF EMBODIMENTS

FIRST EMBODIMENT

Fig. 1 is a top plan view illustrating a first embodiment of an FBG thermal compensating device 10 according to this invention. The device 10 comprises: a substrate 12, means for compressing optical fiber, and an optical fiber 16. In this embodiment, the compressing means includes a metal block 14 affixed to the substrate 12, and the optical fiber 16 is affixed to the substrate 12 and the metal block 14 along a longitudinal direction thereof, wherein the optical fiber 16 is embedded with grids 18 at a mid-section thereof.

As illustrated in Fig. 1, the substrate 12 is formed with a first indent 122 thereon. The first indent 122 has a first length L1 that is greater than a second length L2 of the metal block 14 such that when the metal block 14 is affixed into the first indent 122, the substrate 12 is remained with a space 124.

The substrate 12 is preferably made of quartz; the metal block 14 is preferably made of aluminum or stainless steel. In this embodiment, the optical fiber 16 has an end that is affixed to the substrate 12 at a first affixing point 162, and another end to the metal block 14 at a second affixing point 163 in such a manner that the grids 18 of the optical fiber 16 overlap the metal block 14 and located between the two affixing points 162, 163.

The fiber grids 18 are preferably to be affixed to the substrate and/or metal block by means of instant cured adhesive while the fiber grids 18 are under tension. The optical fiber 16 may alternatively be first adhered to the substrate 12 and the metal block 14 using AB thermally cured adhesive, and then cured to the substrate 12 and the metal block 14 under a thermal state – such as at a temperature of 100°C. The device may further be placed under a thermal state, after the process of thermal curing, for a pre-determined period of time so as to perform annealing to the fiber grids 18 thereby further simplifying the manufacturing process.

When the device experiences thermal effects, such as increment in environmental temperature, the entire device 10 will expand. Because the quartz substrate 12 has a thermal expansion coefficient that is much smaller than the thermal expansion coefficient of the metal block 14, the expansion effect of the quartz substrate 12 can, thus, be neglected.

Under such a state, only the metal block 14, in relation to the entire device 10, expands towards the space 124 thereby compressing the fiber grids 18 located between the two affixing points 162, 163, and causing reduction of the grid wavelength that was increased as a result of increment in environmental temperature. As such, the central wavelength of the fiber grids 18 can be prevented from deviation. The affixing points 162, 163 of the device 10 can be determined by referring to the followings:

Assuming that the fiber grid 18 is not adhered to the metal block 14 while experiencing the aforementioned thermal effects, the effects that the fiber grids 18 experience under such a state may be represented by:

$$\frac{\Delta\lambda_B}{\lambda_B} \cong \xi \, \Delta T \textit{ (Free)}$$

wherein,

λ_B : central wavelength of the FGB

$\Delta\lambda_B$: amount of central wavelength deviation of the fiber grids

ξ : Thermal-Optic Coefficient of the optical fiber

ΔT : change in temperature

On the other hand, if the fiber grids 18 are adhered to the metal block 14 that provides that thermal compensating effects, a negative strain is applied to the fiber grids 18 resulting in change of strain value, such a state may be represented by:

$$\frac{\Delta\lambda_B}{\lambda_B} = (1\text{-}Pe)\,\varepsilon_x \quad \textit{(Axial-Strain)}$$

wherein,

ε_x : axial strain applied to the fiber grids

(1-*Pe*): strain-Optic Coefficient of the optical fiber

In order to achieve the intended compensating effects, it is required that:

$$\frac{\Delta\lambda_B}{\lambda_B}\ \textit{(Free)} + \frac{\Delta\lambda_B}{\lambda_B}\ \textit{(Axial-Strain)} = 0$$

Figs. 4A and 4B illustrate two flowcharts for manufacturing the optical fiber Bragg grating thermal compensating device of Fig. 1. In the devices named in Figs. 4A and 4B, prior to affixing an end of the optical fiber 16 to the affixing point 162, the affixing point 163 is selected on the metal block 14 in accordance with the above equation.

The compensating effects of the first embodiment are as depicted in Fig. 5. The data being referred to as (Free) in Fig. 5 shows the change of wavelength while the device of this invention is not implemented; the data being referred to as (Compensated) in Fig. 5 shows that change of wavelength while the device of this invention is implemented. It is, thus, known from Fig. 5 that, as compared with fiber grids that are not equipped with the compensating device of this invention, the thermal effects that the fiber grids experiences can be significantly reduced.

Referring to Fig. 1A, the FBG thermal compensating device 10 of the first embodiment illustrated in Fig. 1 may further include a manually adjusting means 20 coaxially provided on the substrate 12 along the longitudinal direction of the substrate 12. In the embodiment illustrated in Fig. 1A, the substrate 12 is further formed with a second indent 22 at one end of the substrate 12, and forming two arms 221 and 222 spaced apart along the

longitudinal direction of the substrate 12. A threaded rod 24 having a section of positive screw thread 26 and a section of counter screw thread 28 is disposed across the second indent 22 along the longitudinal direction of the substrate 12, in which the positive screw thread 26 and counter screw thread 28 respectively engage the arms 221 and 222.

In this way, when manually rotating the threaded rod 24 in one direction, the threaded rod 24 drives the arm 222 to gradually get closer to the arm 221. When manually rotating the threaded rod 24 in the other direction, the threaded rod 24 drives the arm 222 to gradually get away from the arm 221. Since one end of the optical fiber 16 is adhered on the arm 222 at the first affixing point 162 of the substrate 12, the distance between the first and second affixing points 162 and 163 can be manually slightly adjusted. The tension and length of the fiber grids 18 located between the affixing points 162 and 163 can be manually adjusted by rotating the threaded rod 24.

SECOND EMBODIMENT

Fig. 2 is a top plan view illustrating a second embodiment of an FBG thermal compensating device 10' according to this invention. The device 10' comprises: a substrate 12', means for compressing optical fiber, and an optical fiber 16'. In this embodiment, the compressing means includes a first metal block 14' and a second metal block 142' each affixed to the substrate 12', and the optical fiber 16' is affixed to the two metal blocks 14', 142' along a longitudinal direction thereof, wherein the optical fiber 16' is embedded with grids 18' at a mid-section thereof.

As illustrated in Fig. 2, the substrate 12' is formed with an indent 122' thereon. The indent 122' has a first length L1 that is greater than sum of a second and third length L2, L3 of the respective metal blocks 14', 142' such that when the two metal blocks 14', 142' are affixed into the indent 122', the substrate 12' is remained with a space 124'. The fiber grids 18' further have an overall length LG being slightly smaller than the difference between the first length L1 and the sum of L2, L3.

The substrate 12' is preferably made of quartz; the metal blocks 14', 142' are preferably made of aluminum or stainless steel. In this embodiment, the optical fiber 16' has an end that is affixed to the first metal block 14' at a first

affixing point 163', and another end to the second metal block 142' at a second affixing point 162' in such a manner that the grids 18' of the optical fiber 16' happen to be exposed next to the space 124'.

The fiber grids 18' are preferably to be affixed to metal blocks by means of instant cured adhesive while the fiber grids 18' are under tension. The optical fiber 16' may alternatively be first adhered to the metal blocks 14', 142' using AB thermally cured adhesive, and then cured to the metal blocks 14', 142' under a thermal state – such as at a temperature of 100°C. The device may further be placed under a thermal date, after the process of thermal curing, for a pre-determined period of time so as to perform annealing to the fiber grids 18' thereby further simplifying the manufacturing process.

When the device experiences thermal effects, such as increment in environmental temperature, the entire device 10' will expand. Because the quartz substrate 12' has a thermal expansion coefficient that is much smaller than the thermal expansion coefficient of the metal blocks 14', 142', the expansion effect of the quartz substrate 12' can, thus, be neglected.

Under such a state, only the metal blocks 14', 142', in relation to the entire device 10', expand towards the space 124' thereby compressing the fiber grids 18', and causing reduction of the grid wavelength that was increased as a result of increment in environmental temperature. As such, the central wavelength of the fiber grids 18' can be prevented from deviation. The affixing points 162', 163' of the device 10' can be determined by referring to the equation discussed in the first embodiment.

Figs. 4C and 4D illustrate two flowcharts for manufacturing the optical fiber Bragg grating thermal compensating device of Fig. 2. In the devices named in Figs. 4C and 4D, prior to affixing an end of the optical fiber 16' to the second metal block 142' at the affixing point 162, the affixing point 163' is selected on the metal block 14' in accordance with the above equation.

Referring to Fig. 2A, the FBG thermal compensating device 10' of the second embodiment illustrated in Fig. 2 may further include a manually adjusting means 20' coaxially provided on the substrate 12' along the longitudinal direction of the substrate 12'. Similar to the embodiment illustrated in Fig. 1A and described hereinbefore, the distance between two

arms 221' and 222' can be adjusted by rotating the threaded rod 24', and the distance between the first and second affixing points 162' and 163' can be manually slightly adjusted. The tension and length of the fiber grids 18' located between the affixing points 162' and 163' can be manually adjusted by rotating the threaded rod 24'.

THIRD EMBODIMENT

Fig. 3 is a top plan view illustrating a third embodiment of an FBG thermal compensating device 10" according to this invention. The device 10" comprises: a substrate 12", means for compressing optical fiber, and an optical fiber 16". In this embodiment, the compressing means includes a first metal block 14" and a compensating block 19" each affixed to the substrate 12", and the optical fiber 16" is adhered to the compensating block 19" along a longitudinal surface thereof, wherein the optical fiber 16" is embedded with grids 18" at a mid-section thereof.

As illustrated in Fig. 3, the substrate 12" is formed with an indent 122" thereon. The indent 122" has a first length L1 that is greater than a second length L2 of the metal block 14" such that when the metal block 14" is affixed into and end of the indent 122", the substrate 12" is remained with a space (not numerated) between the substrate 12" and the metal block 14" for receiving the compensating block 19". The grids 18" further have an overall length LG being slightly smaller than a fourth length L4 of the compensating block 19".

The substrate 12" is preferably made of quartz; the metal block 14" is preferably made of aluminum or stainless steel; the compensating block 19" is preferably made of pliable material.

The grids 18" are preferably adhered to the compensating block 19" along their surfaces by means of instant cured adhesive, such that the grids are located next to the compensating block 19".

When the device experiences thermal effects, such as increment in environmental temperature, the entire device 10" will expand. Because the quartz substrate 12" has a thermal expansion coefficient that is much smaller than the thermal expansion coefficient of the metal block 14" and the

compensating block 19", 142", the expansion effect of the quartz substrate 12" can, thus, be neglected.

Under such a state, only the metal block 14", in relation to the entire device 10", expands towards the compensating block 19" thereby causing the compensating block 19" to drive axial compression of the fiber grids 18", and causing reduction of the grid wavelength that was increased as a result of increment in environmental temperature. As such, the central wavelength of the fiber grids 18" can be prevented from deviation. The relative length of the metal bock and the compensating block can be designated by referring to the equation discussed in the first embodiment. However, in the embodiment, special attention should be given to the Young's modulus of the metal block and the compensating block, where the Young's modulus of the metal block is always greater than that of the compensating block.

Fig. 4E illustrates the flowchart for manufacturing the optical fiber Bragg grating thermal compensating device of Fig. 3.

Referring to Fig. 3A, the FBG thermal compensating device 10" of the third embodiment illustrated in Fig. 3 may further include a manually adjusting means 20" coaxially provided on the substrate 12" along the longitudinal direction of the substrate 12". In the embodiment illustrated in Fig. 3A, the substrate 12" is further formed with a second indent 22" at one end of the substrate 12", and forming two arms 221" and 222" spaced apart along the longitudinal direction of the substrate 12". A threaded rod 24" having a section of positive screw thread 26" and a section of counter screw thread 28" is disposed across the second indent 22" along the longitudinal direction of the substrate 12", in which the positive screw thread 26" and counter screw thread 28" are respectively engage the arms 221" and 222".

In this way, when manually rotating the threaded rod 24" in one direction, the threaded rod 24" drives the arm 222" to gradually get closer to the arm 221". When manually rotating the threaded rod 24" in the other direction, the threaded rod 24" drives the arm 222" to gradually get away from the arm 221". The distance between the metal block 14" and the second arm 222" that forms a space for receiving the compensating block 19" can be manually slightly adjusted. Since the fiber grids 18" are adhered to the compensating block 19" along their surfaces, and the compensating block 19" is disposed

between the metal block 14" and the second arm 222", the tension and length of the fiber grids 18" can be manually adjusted by rotating the threaded rod 24".

FOURTH EMBODIMENT

Fig. 6 is a top plan view illustrating a fourth embodiment of an FBG thermal compensating device 6 according to this invention. The device 6 comprises: a substrate 62, means for compressing optical fiber, and an optical fiber 66. In this embodiment, the compressing means includes a layer of thin film 64 having a thermal expansion coefficient greater than a thermal expansion coefficient of the substrate 62 and integrally surrounding and firmly coating on a section of the optical fiber 66, and the optical fiber 66 is affixed to the substrate 62 along a longitudinal direction thereof, wherein the optical fiber 66 is embedded with grids 68 at a mid-section thereof.

As illustrated in Fig. 6, the substrate 62 is formed with a first indent 622 thereon. The first indent 622 has a first length L1 that is greater than a fifth length L5 of the thin film 64 such that the thin film 64 is allowed to expand along the longitudinal direction of the optical fiber 66 within the first indent 622.

The substrate 62 is preferably made of quartz; the thin film 64 is preferably made of metal such as aluminum or copper , or mixture of metallic powder and epoxy resin. In this embodiment, the optical fiber 66 has two ends respectively affixed to the substrate 62 at a first affixing point 662 and at a second affixing point 663 in such a manner that the grids 68 of the optical fiber 66 and the thin film 64 are located between the two affixing points 662 and 663.

Sub a4

The fiber grids 68 are preferably to be affixed to the substrate by means of instant cured adhesive while the fiber grids 68 are under tension.

When the device experiences thermal effects, such as increment in environmental temperature, the entire device 6 will expand. Because the thermal expansion coefficient of the quartz substrate 62 is much smaller than the thermal expansion coefficient of the thin film 64, the expansion effect of the quartz substrate 62 can, thus, be neglected.

Because the grids 68 and the thin film 64 are located between two affixing points 662 and 663, and the thermal expansion coefficient of the thin film 64 is greater than the thermal expansion coefficient of the substrate 62, only the thin film 64, in relation to the entire device 6, expands towards the fiber grids 68 thereby compressing the fiber grids 68 against the affixing point 662, and causing reduction of the grid wavelength that was increased as a result of increment in environmental temperature. As such, the central wavelength of the fiber grids 68 can be prevented from deviation.

The length L5 of the thin film 64 can be designated by referring to the equation discussed in the first embodiment.

Figs. 8A and 8B illustrate two flowcharts for manufacturing the optical fiber Bragg grating thermal compensating device of Fig. 6. In the devices named in Figs. 8A and 8B, prior to affixing an end of the optical fiber 66 to the substrate 62 at the affixing point 662, the affixing point 663 and the longitudinal length L5 of the thin film 64 are determined in accordance with the above equation.

Referring to Fig. 6A, the FBG thermal compensating device 6 of the fourth embodiment illustrated in Fig. 6 may further include a manually adjusting means 60, similar to the manually adjusting means 20, 20' and 20" illustrated in Figs. 1A, 2A and 3A, coaxially provided on the substrate 62 along the longitudinal direction of the substrate 62, so as to manually adjust an axial tension of the optical fiber 66 located between two affixing points 662 and 663 along the longitudinal direction of the substrate 62,

FIFTH EMBODIMENT

Fig. 7 is a top plan view illustrating a fifth embodiment of an FBG thermal compensating device 7 according to this invention. The device 7 comprises: a substrate 72, means for compressing optical fiber, and an optical fiber 76. In this embodiment, the compressing means includes a floating metal block 74 affixed to the optical fiber 76 at two affixing points 741 and 742 along a longitudinal direction of the optical fiber 76 and having a thermal expansion coefficient greater than a thermal expansion coefficient of the substrate 72, and the optical fiber 76 is affixed to the substrate 72 along the longitudinal direction thereof, wherein the optical fiber 76 is embedded with grids 78 at a

mid-section thereof.

As illustrated in Fig. 7, the substrate 72 is formed with a first indent 722 thereon. The first indent 722 has a first length L1 that is greater than a sixth length L6 of the floating metal block 74 such that the floating metal block 74 is allowed to expand along the longitudinal direction of the optical fiber 76 within the first indent 722.

The substrate 72 is preferably made of quartz; the floating metal block 74 is preferably made of aluminum or stainless steel. In this embodiment, the optical fiber 76 has two ends respectively affixed to the substrate 72 at a first affixing point 762 and at a second affixing point 763 in such a manner that the fiber grids 78 of the optical fiber 76 and the floating metal block 74 are located between two affixing points 762 and 763.

The fiber grids 78 are preferably to be affixed to the substrate 72 and/or floating metal block 74 by means of instant cured adhesive while the fiber grids 68 are under tension.

When the device 7 experiences thermal effects, such as increment in environmental temperature, the entire device 7 will expand. Because the thermal expansion coefficient of the quartz substrate 72 is much smaller than the thermal expansion coefficient of the floating metal block 74, the expansion effect of the quartz substrate 72 can, thus, be neglected.

Because the fiber grids 78 and the floating metal block 74 are located between two affixing points 762 and 763, and the thermal expansion coefficient of the floating metal block 74 is much greater than the thermal expansion coefficient of the optical fiber 76, only the floating metal block 74, in relation to the entire device 7, expands towards the fiber grids 78 thereby compressing the fiber grids 78 against the affixing point 762, and causing reduction of the grid wavelength that was increased as a result of increment in environmental temperature. As such, the central wavelength of the fiber grids 78 can be prevented from deviation.

The distance between the affixing points 741 and 742 and the length L6 of the floating metal block 74 can be designated by referring to the equation discussed in the first embodiment.

Preferably, the floating metal block 74 is adhered to the substrate 72 by elastically deformable adhesive 75, such as rubber or soft gel, so that the floating metal block 74 is freely expandable along the longitudinal direction of the optical fiber 76.

Figs. 8C and 8D illustrate two flowcharts for manufacturing the optical fiber Bragg grating thermal compensating device of Fig. 7. In the devices named in Figs. 8C and 8D, prior to affixing an end of the optical fiber 76 to the substrate 72 at the affixing point 762, the affixing point 763 and the longitudinal length L6 of the thin metal block 74 are determined in accordance with the above equation.

Referring to Fig. 7A, the FBG thermal compensating device 7 of the fifth embodiment illustrated in Fig. 7 may further include a manually adjusting means 70, similar to the manually adjusting means 20, 20', 20" and 60 illustrated in Figs. 1A, 2A, 3A and 6A, coaxially provided on the substrate 72 along the longitudinal direction of the substrate 72, so as to manually adjust an axial tension of the optical fiber 76 located between two affixing points 762 and 763 along the longitudinal direction of the substrate 72,As compared with the conventional FBG thermal compensating devices having a bi-metal construction, the thermal compensating devices according to this invention consist the advantages of simple constructions and simplified manufacturing processes. Based on the first embodiment of this invention, determination of the length of the metal block allows heat can be conducted to the metal block in an expeditious manner so as to allow immediate response of the metal block to the thermal expansion of the fiber grids. Based on the second embodiment of this invention, the device allows rapid positioning and manufacturing. Based on the first and second embodiments of this invention, when the fiber grids are cured to the device using AB thermally cured adhesive under a thermal state, the need for applying a pre-load is eliminated; the device can also be placed under a thermal state, after the process of thermal curing, for a pre-determined period of time so as to perform annealing to the fiber grids thereby further simplifying the manufacturing process. Based on the third embodiment of this invention, the fiber grids are secured to the device under a load-free, and room temperature state, thereby eliminates the need of applying a pre-load.

Based on the fourth or fifth embodiment of this invention, since the metal thin film 64 or floating metal block 74 can be secured to anywhere on the optical fiber 66 or 76 located between the first affixing point 662 and second affixing point 663 on the substrate 62, the design, manufacture and assembling the device can be further simplified.

Aforementioned explanation is directed to the description of the preferred embodiment according to the present invention. Various changes and implementations can be made by personals skilled in the art without departing from the technical concept of the present invention. Since the present invention is not limited to the specific details described in connection with the preferred embodiment except those that may be within the scope of the appended claims, changes to certain features of the preferred embodiment without altering the overall basic function of the invention are contemplated.